HRSG Drum Level Control

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HRSG Drum Level Control Valve Applications for Power Plants

Introduction

In the past, most power plants were base loaded coal fired boilers that operated at or near the maximum generator output most of the time. The exceptions to the rule were during startup or an upset condition. These plants typically used large steam driven boiler feed pumps, which could ramp the boiler feed pump to meet the boiler demand. The startup boiler feed pump is usually a smaller motor driven pump. As a result of these arrangements, most plants used a two-valve arrangement; a large main valve for normal operation and a startup valve to handle up to 30% of the normal flow rate but with an anti-cavitation trim to handle the higher pressure drops during startup of the unit.

As combustion turbines have become more prevalent, the boiler feed pumps have changed. In general the boiler feed pumps are smaller. Steam driven pumps are not economical, as all of the steam is being sent to the turbine to maximize the plant output. Variable speed drives are rarely used due to the cost associated and the additional power required with these drives. As a result, most boiler feed pumps for HRSG units are driven using single speed electric motors.

As with any pump curve, the problem associated with a single speed motor driven pump is the pump head increases as the flow decreases. With a single speed motor driven pump, the pressures associated with the minimum recommended flow rate of the pumps can be as high as 25-40% above the normal operating pressure of the system. The additional pressure added by the pumps at the lower operating flow rates must be eliminated by the drum level control valve to prevent a system upset.

Another feature of the combined cycle plants is the rapid startup and load changing characteristics of these units. A combustion turbine and HRSG arrangement can be started and brought up to full load in a relatively short period of time compared to a large coal fired unit. This characteristic makes these plants ideal for peaking plant operation. In addition, a sliding pressure operation is frequently used on combined cycle plants to provide more efficient operation of the unit. In sliding pressure operation, the boiler feed pump outlet pressure will remain the same but the drum level operating pressure is reduced below the normal operating pressure. The drum level control valve has to eliminate the pressure associated with this differential.

The combination of single speed, motor driven boiler feed pumps, peaking and partial load operation, and sliding pressure operation require additional consideration be given to the drum level control valve arrangement. Following are three different arrangements that can be used based for this application. Careful consideration should be given to the operating pressures, planned or actual plant operation, size, and type of unit.

Arrangement 1: 30% Capacity Startup Valve and 100% Main Base Load Valve

Arrangement 1 is a two-valve arrangement consisting of a startup valve sized to provide 30% of the maximum operating load and a main valve sized for 100% of the maximum operating load. Both valves are in parallel. This arrangement can also be modified to include two 50% capacity main base load valves if desired by the end user. The startup valve will have anti-cavitation trim capable of handling the maximum pressure drop associated with a cold startup of the unit. The main valve will include standard trim and is designed for relatively low-pressure drops (less than 250 psig).

The operating principle of this arrangement calls for the startup valve to be used until the unit is up to at least 30% capacity load. At this point, the pressure drop across the valve station is such that operation can be switched to the 100% main base load valve for operation up to 100% plant load. For larger, higher-pressure CT/HRSG trains, the base load valve is typically a 4-inch valve and the startup valve can range from a 2 inch to 4-inch valve with anti-cavitation trim. The valve sizes will change based upon size of the unit, anticipated flow rates, and pressure drops.

Arrangement 1 is the standard configuration used on most drum level control valve operations in the past and is considered the industry standard for this application. This arrangement will be the most cost effective of the three arrangements as only one of the valves uses anti-cavitation trim. As there is a lower level of cavitation protection, additional care and consideration must be given to the selection of this arrangement.

Arrangement 1 should only be used on true base load units (i.e. units that will only operate at or near 100% load most of the time). If there is any possibility the plant will be used as a peaking unit or in partial load operation, this arrangement should not be used. As the 100% base load valve does not include anti-cavitation trim, the allowable pressure drops across this valve are relatively low (typically less than 400 psig). If this arrangement is used in sliding pressure or partial load operation, the pressure drop across the main valve will increase dramatically. Actual documented cases exist where the pressure drops across the valve were in the range of 1200-1500 psig. At these pressure drops, cavitation damage to the valve will occur very quickly. The startup valve does not have the capacity to meet the flow requirements so the plant will have no option but to operate the main valve in a damaging situation.

In recent experience, Arrangement 1 has not been a good selection for a combined cycle/cogeneration plants. The engineering contractors design the unit for base load operation and provide these base load cases for valve selection. Due to the shortened design and construction schedules, the contractor does not always have the time and resources to investigate sliding pressure or partial load operation. Once the owner takes control of the plant operation, the operators begin running the plant in sliding pressure mode which was not included in the original valve specifications. As a result, the main valves were experiencing cavitation damage due to the large pressure drops being taken across these valves. The solution was to move to Arrangement 3 by installing a characterized anti-cavitation cage in the main valve. For this reason, it is crucial to determine if sliding pressure or partial load operation will be required for this valve arrangement.

Arrangement 2: One Valve With Characterized Anti-Cavitation Trim

Arrangement 2 consists of a single control valve that combines the operation of the startup valve and the main valve through the use of a characterized anti-cavitation cage. A characterized cage is a specially designed cage that has anti-cavitation protection at the lower end of the flow range and the level of protection decreases as the valve opens. There are characterized cages that have Cav III 3 stage protection at the lower end of the flow range and standard trim characteristics at the upper end of the flow range. Fisher Controls specially designed these cages for drum level control valve applications.

The operating principle of this arrangement is much simpler than Arrangement 1 as there is only one valve. Only one signal is required from the plant control system so the system logic is much less complicated. For the larger, higher-pressure CT/HRSG trains, the control valve is typically a 6-inch valve anti-cavitation trim. Typically the level of cavitation trim must be rated for the same level as the boiler feed recirculation valves. The valve size will change based upon size of the unit, anticipated flow rates, and pressure drops.

Arrangement 2 is much less common that Arrangement 1. The main reason is that Arrangement 1 is considered the industry standard. A one-valve configuration is often regarded as a design modification. Another reason is the cost of the valve for this arrangement is greater than the cost of both valves in Arrangement 1 combined. The third and main reason is many times a single valve cannot meet all of the operating conditions required. It is important to consider that the total in-

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stalled cost of Arrangement 2 is actually less than Arrangement 1, if the costs associated with the additional piping, block valves, wiring, and logic are factored into the total costs. An additional benefit of this arrangement is space. One valve train will take up less room than two.

As in Arrangement 1, care must be taken to ensure the proper cage is selected to meet all of the operating conditions. It is possible to select a single cage that will meet all of the operating conditions for base load operation as well as the peaking and partial load operating cases. To make this selection, the cases which set all of the operating parameters must be provided by the engineering contractor or end user. The more operating cases that can be provided from the engineering contractor/end user, detailing the conditions the valve will experience, the better the cage that will be selected. It is possible that a cage will meet most operating conditions with the exception of one case. That one operating point may result in cavitation at that specific operating point. After analysis it may be determined the plant will only see that operating case a few times in its operating life and these cases will be for short durations only.

Another disadvantage of the single valve arrangement surfaces if the plant operation changes from the design cases that were originally provided. In these instances, one is limited in the site changes that can be performed. A two-valve arrangement does provide greater flexibility. This flexibility is best demonstrated in Arrangement 3 below.

Arrangement 3: 10% Capacity Startup Valve and 100% Main Base Load Valve with Characterized Anti-Cavitation Trim

Arrangement 3 is a combination of Arrangements 1 and 2 that Experitec has been quoting to engineering contractors. The configuration is also a two-valve arrangement consisting of a startup valve and main valve sized for 100% of the maximum operating load. The difference is the startup valve is sized for approximately 10% capacity and includes an anti-cavitation cage rated at the same level as the boiler feed pump recirculation valve. This valve is used for startup and boiler fill only. The 100% Main Base load valve is similar to the valve in Arrangement 2 in that it has a characterized anti-cavitation trim. The anti-cavitation trim in this case is one step lower than the startup valve.

The operating principle of this arrangement is the startup valve is used until the valve position is approximately 80% open or until the system flow rate reaches a certain point. At this point, the pressure drop across the valves will be such that the main valve can open and meet the operating conditions without damage to the cage. The startup valve is then closed as the main valve is opened and operated up to 100% load. For larger, higher-pressure CT/HRSG trains, the base load valve is typically a 4 or 6-inch valve and the startup valve is typically a 3 valve. The valve sizes will change based upon size of the unit, anticipated flow rates, and pressure drops.

Arrangement 3 does result in the highest initial cost associated with this application, but it also provides a more robust durable solution. The valves in this arrangement last longer and require less maintenance and rework. In some cases, initial designs employing Arrangement 1 or 2 ultimately are reworked into Arrangement 3 to realize the best performance.

As in Arrangement 2, care must be taken to ensure the proper cage is selected for the main valve to meet all of the operating conditions. As a lower level of anti-cavitation protection is used in the main valve, the coverage areas for the remaining cavitation protection are higher. Therefore it is much easier to find a characterized cage which can meet all of the operating conditions associated with base, peaking, and partial load operation. It is still imperative that as many operating conditions as possible be provided from the engineering contractor/end user to ensure the proper cage is selected.

Summary

Each drum level control valve application is unique. Plant operating schemes, flow rates, pressure drops, owner preference, and plant type all play a role in determining the best arrangement for the plant. The above analysis has tried to provide rough guidelines into the available options and when to use each arrangement.

The analysis listed above has been based upon the larger base load HRSG/Combustion turbine arrangements using the larger General Electric, Siemens-Westinghouse, ABB, and Mitsubishi combustion turbines which operating at elevated boiler feed pump discharge pressures (2500-3500 psig). These arrangements can also be applied to smaller package type boilers as well as lower pressure applications but generally the level of anti-cavitation protection required is minimal.

Each of the above configurations has been proven to operate effectively in a given application providing the design and operating parameters for that configuration are met. As always, the key to selecting the proper arrangement is to get as much information as possible from the engineering contractor/end user as to how the plant will be operated and the conditions the valves operate under.